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(54) Title: FILTER ELEMENT, AIR CLEANER, AND METHODS

(57) Abstract: A filter arrangement includes a filter element, a frame construction secured to the filter element, and a handle member secured to the filter element. In preferred embodiments, the handle member is secured to the frame construction. Preferably, the filter element includes a central core member, wherein fluted filter media is coiled around the central core member. Preferably, the central core member includes a plurality of corrugations, wherein the corrugations mateably engage at least some flutes. Preferably, the handle member is integral with the central core member, and also includes a fastening member for connection to a frame construction on the filter element. Methods for cleaning air and servicing an air cleaner preferably include construction as described herein.

## FILTER ELEMENT, AIR CLEANER, AND METHODS

### Technical Field

This disclosure describes filter constructions for filtering fluids, such as gas or liquid. In particular, this disclosure describes a filter element having a centerpiece, methods for servicing an air cleaner, and methods for constructing a filter element having a centerpiece.

### Background

Straight through flow filter elements have been used in systems for cleaning fluid passing therethrough. Straight through flow filter elements typically will have an inlet face and an oppositely disposed outlet face. In this manner, fluid flows in one certain direction upon entering the filter element at the inlet face and will have the same direction of flow as it exits the outlet face. Typically, straight through flow filter elements will be installed in a duct or housing of some type. After a period of use, the filter element will require servicing, either cleaning or a complete replacement. If it is difficult or inconvenient to service the filter element, the user may delay the proper servicing, which can cause damage to whatever system is being filtered.

Improvements to straight through flow filter elements are desirable.

### Summary of the Disclosure

The disclosure describes a filter arrangement including a filter element, a frame construction secured to the filter element, and a handle member secured to the filter element. In preferred arrangements, the filter element includes a plurality of flutes, wherein each of the flutes have a first end portion adjacent to a first end of the filter element, and a second end portion adjacent to a second end of the filter element. Selected ones of the flutes are open at the first end portion and closed at the second end portion, while selected ones of the flutes are closed at the first end portion and open at the second end portion.

In preferred arrangements, the handle member is secured to the frame construction.

In certain preferred embodiments, the filter element includes a central core member, wherein the plurality of flutes are coiled around the central core member. Preferably, the handle member will be secured to the central core member. In preferred embodiments, the central core member includes a plurality of  
5 corrugations, wherein the corrugations mateably engage at least some of the flutes.

The disclosure also describes a center board for use in a filter element. Preferred center boards include an extension having first and second opposite ends, and a region of corrugation located on the extension between the first and second ends. The region of corrugation is constructed and arranged to mate with  
10 fluted media of a filter element.

Preferably, the center board will include a handle member forming the first end, and a fastening member forming the second end. The fastening member is preferably constructed and arranged to connect to a frame construction of the filter element.

15 The disclosure also describes an air cleaner including a housing and a filter element removably positioned in the housing. The housing includes a body member and a cover. The cover includes a projection extending in a direction toward an interior of the body member. The filter element preferably includes a center board extending at least partially into the filter element. Preferably, the center  
20 board includes a first portion axially extending from a flowface of the filter element. In preferred embodiments, the projection of the cover will engage the first portion of the center board, when the filter element is operably installed in the interior, and when the cover is operably oriented over an open end of the body member.

The disclosure also describes a method for servicing an air cleaner.  
25 The method includes providing a filter element installed in a housing. The filter element includes a frame construction secured thereto. The method includes a step of grasping a handle secured to the frame construction, and pulling the handle to remove the filter element from the housing. Preferred methods will utilize filter element constructions as characterized herein.

30 Methods for constructing air filter elements are also described. In preferred methods, there is a step of providing a center board having first and second opposite ends and a region of corrugation at least partially located between the first

and second ends. Selected flutes of fluted filter media are aligned with the region of corrugation. The fluted filter media is then wound around the center board.

### **Brief Description of the Drawings**

FIG. 1 is a schematic view of one embodiment of a system having an engine with an air intake system and an air cleaner constructed according to principles disclosed herein.

FIG. 2 is a schematic, cross-sectional view of one embodiment of an air cleaner, including an air cleaner housing and a filter element operably installed therein, constructed according to principles of this disclosure.

FIG. 3 is a schematic, exploded, side elevational view of the air cleaner depicted in FIG. 2.

FIG. 4 is a schematic, perspective view of one embodiment of a portion of filter media usable in the filter element depicted in FIGS. 2 and 3.

FIG. 5 is a schematic, perspective view of the embodiment of the air filter element depicted in FIGS. 2 and 3.

FIG. 6 is a schematic, perspective view of one embodiment of the filter element depicted in FIG. 5, and shown from an opposite end.

FIG. 7 is a schematic, exploded, side elevational view of one embodiment of the filter element depicted in FIGS. 5 and 6.

FIG. 8 is a top plan view of one embodiment of a center board usable in the filter elements depicted in FIGS. 2, 3, and 5-7.

FIG. 9 is an enlarged cross-sectional view of the center board of FIG. 8, and taken along the line 9-9 of FIG. 8.

### **Detailed Description**

#### **A. FIG. 1, System of Use**

The air cleaner arrangements and constructions disclosed herein are usable in a variety of systems. FIG. 1 depicts one particular system, shown schematically at 20. In FIG. 1, equipment 22, such as a vehicle, having an engine 24 with some defined rated airflow demand, for example, about 500-700 CFM, is shown schematically. Equipment 22 may comprise a bus, a highway truck, an off-

road vehicle, a tractor, or marine application such as a powerboat. Engine 24 powers equipment 22, through the use of an air, fuel mixture.

In FIG. 1, airflow is shown drawn into the engine 24 through an air intake system 26. The air intake system 26 includes an air cleaner 28, and air is  
5 taken into the air cleaner 28 at arrow 30.

A primary filter element 32 is shown upstream of the engine 24 to remove particles and contaminants from the air. Downstream of the primary filter element 32 may be an optional safety element 34. The safety element 34 is also upstream of the engine 24 to remove any particles and contaminants that did not get  
10 removed by the primary element 32.

The air is cleaned in the air cleaner 28, and then it flows downstream at arrow 36 into the intake 26. From there, the air flows into the engine 24 to power the equipment 22. An optional turbo 38 may be used to boost the power.

#### B. Overview of Air Cleaner

15 One example of an air cleaner 28 usable in system 20 is shown in cross-section in FIG. 2 at 50. In general, the air cleaner 50 holds a removable and replaceable filter element 52 within its interior 54. The air cleaner 52 includes an inlet 56 and an outlet 58. Air to be cleaned is directed into the air cleaner 50 through the inlet 56, through the filter element 52, and then out through the outlet 58. The  
20 air will typically then be directed into an air intake system, such as intake 28 for engine 24. The filter element 52, when operably installed in the housing 51, will remove substantial portions of particulate matter from the air or gas flow stream directed therethrough.

Still in reference to FIG. 2, the filter element 52 is configured to  
25 permit straight through flow. By the term "straight through flow," it is meant that the fluid flows directly through the filter element 52, entering at an inlet face 60 and exiting at an oppositely disposed outlet face 62, wherein the direction of fluid flow entering the inlet face 60 is in the same direction of fluid flow exiting the outlet face 62. For example, the filter element 52 has a first end 64 and an opposite, second end  
30 66. In the arrangement depicted in FIG. 2, the first end 64 will correspond to an upstream end inlet face 60, while the second end 66 will correspond to a downstream end outlet face 62. Other arrangements may include the first end 64 as

corresponding to the outlet face, while the second end 66 corresponds to the inlet face. The straight through flow allows gas to flow into the first end 64 and exit the second end 66, such that the direction of the air flow into the first end 64 is the same direction of air flow that is exiting the second end 66. Straight through flow patterns  
5 can reduce the amount of turbulence in the gas flow.

Still in reference to FIG. 2, there is also a handle member 70 secured to the filter element 52, to assist in servicing the air cleaner 50. In particular, the handle member 70 assists in the convenient removal of the filter element 52, to service the air cleaner 50. The handle member 70 is described in further detail  
10 below. FIG. 2 also illustrates a frame construction 72 secured to the filter element 52. As will be described in further detail below, the frame construction 72, in preferred embodiments, supports a seal member 74 to create a seal, preferably a radial seal 76, between the filter element 52 and the housing 51. The frame construction 72 also, in preferred embodiments, engages the handle member 70.  
15 This is discussed further below.

### C. The Housing

Attention is directed to FIGS. 2 and 3. The housing 51 preferably includes two pieces, a body member 80 and a removable cover 82. Body member 80 defines the open interior 54 (FIG. 2) and an open end 84. The open end 84 is for  
20 receiving the filter element 52 therethrough. The cover 82 is selectively movable from the open end 84 of the body member 80, in order to provide access to the interior 54. For example, during servicing of the air cleaner 50, the cover 82 can be removed to provide access to the filter element 52.

The cover 82 includes fasteners, such as bolts 86 (FIG. 3) for  
25 securing the cover 82 to the body member 80.

In general, the air cleaner 50 includes a stay member 87 that will help to keep the filter element 52 properly oriented in the body member 80. The stay member 87 will also function as an indicator to communicate to the user if the user has not initially properly installed the filter element 52 in the body member 80. By  
30 "properly installed," it is meant that the filter element 52 is oriented and seated within the interior 54, and the radial seal 76 is in place.

While a variety of embodiments for the stay member 87 are contemplated, in the particular embodiment illustrated, the stay member 87 comprises a projection 88 extending from the cover 82 in a direction toward the interior 54, when the cover 82 is operably oriented over the open end 84 of the body member 80. The projection 88 helps to hold the filter element 52 in place within the  
5     body member 80, during operation. Vibration and other factors could try to knock the filter element 52 loose within the housing 51 during operation. The projection 88 helps to keep the filter element 52 properly seated and installed.

In the embodiment illustrated in FIG. 3, the projection 88 includes an  
10     elongate extension 90, extending from and integral with the cover 82. In particular, the extension 90 is located at about the center 92 (FIG. 2) of the cover 82. The extension 90 is preferably angled between about 80-100°, preferably about 90°, relative to the inside surface 94 of the cover 82. The extension 90 includes a  
15     generally flat, element engaging end 96. As such, the extension 90 comprises a cantilevered beam 97 with a fixed end at the cover 82 and a free end at the element engaging end 96. Preferably, the extension 90 will have a width 98 (FIG. 2) that is smaller than a void 100 (FIG. 2) formed in the handle member 70.

In reference again to FIG. 2, the body member 80 has in its interior  
20     54 a first annular region 102 and a second annular region 104. The second annular region 104 is smaller or reduced relative to the first annular region 102. This creates a shoulder 106 at the transition between these two regions. There is also an end wall 108 terminating the second annular region 104. The second annular region 104, together with the end wall 108, forms a seat 110 for receiving the frame construction 72 with the seal member 74. The filter element 52 is properly oriented in the  
25     housing 51, when the seal member 74 is compressed against the second annular region 104 to form radial seal 76 against the second annular region 104. The end wall 108 helps to orient the filter element 52, and prevent it from being pushed downstream, past the second annular region 104.

It should be appreciated that the radial seal 76 helps to prevent  
30     unintended gas flow from flowing around the filter element 52 and avoiding the filtering affect of the filter element 52. That is, the radial seal 76 helps to force the

gas flow coming through the inlet 56 to travel through the filter element 52, in order to reach the outlet 58.

The body member 80 also includes a sloped wall portion 112 extending from the end wall 108 toward the outlet 58. The sloped wall portion 112 helps to direct the filtered or cleaned gas from the outlet face 62 through the outlet 58.

#### D. The Filter Element

The filter element 52 will now be described in further detail.

Attention is directed to FIG. 4. FIG. 4 is a schematic, perspective view demonstrating the principles of operation of certain preferred media usable in the filter construction herein. In FIG. 4, a fluted construction is generally designated at 122. Preferably, the fluted construction 122 includes: a layer 123 of corrugations having a plurality of flutes 124 and a face sheet 132. The FIG. 4 embodiment shows two sections of the face sheet at 132A (depicted on top of the corrugated layer 123) and at 132B (depicted below the corrugated layer 123). Typically, the preferred fluted construction 122 will include the corrugated layer 123 secured to the bottom face sheet 132B. When using this fluted construction 122 in a rolled construction, it typically will be wound around itself, such that the bottom face sheet 132B will cover the top of the corrugated layer 123. The face sheet 132 covering the top of the corrugated layer 123 is depicted as 132A. It should be understood that the face sheet 132A and 132B are the same sheet 132.

When using this type of fluted construction 122, the flute chambers 124 preferably form alternating peaks 126 and troughs 128. The troughs 128 and peaks 126 divide the flutes into an upper row and a lower row. In the particular configuration shown in FIG. 4, the upper flutes form flute chambers 136 closed at the downstream end, while flute chambers 134 having their upstream end closed form the lower row of flutes. The fluted chambers 134 are closed by a first end bead 138 that fills a portion of the upstream end of the flute between the fluting sheet 130 and the second facing sheet 132B. Similarly, a second end bead 140 closes the downstream end of alternating flutes 136. In some systems, both the first end bead 138 and second end bead 140 are straight all along portions of the fluted construction 122, never deviating from a straight path.



When using media constructed in the form of fluted construction 122, during use, unfiltered fluid, such as air, enters the flute chambers 136 as indicated by the shaded arrows 144. The flute chambers 136 have their upstream ends 146 open. The unfiltered fluid flow is not permitted to pass through the downstream ends 148 of the flute chambers 136 because their downstream ends 148 are closed by the second end bead 140. Therefore, the fluid is forced to proceed through the fluting sheet 130 or face sheets 132. As the unfiltered fluid passes through the fluting sheet 130 or face sheets 132, the fluid is cleaned or filtered. The cleaned fluid is indicated by the unshaded arrow 150. The fluid then passes through the flute chambers 134, which have their upstream ends 151 closed to flow through the open downstream ends out the fluted construction 122. With the configuration shown, the unfiltered fluid can flow through the fluted sheet 130, the upper facing sheet 132A, or the lower facing sheet 132B and into a flute chamber 134.

The fluted construction 122 is typically wound into a rolled or coiled form, such as shown in FIG. 5. A variety of ways can be used to coil or roll the fluted construction 122. In constructing the filter element 52, typically the fluted construction 122 is wound around the handle member 70 in a coil or spiral pattern thereabout. This is described in further detail below. Referring again to FIG. 5, note the cross-sectional shape of the filter element 52 is non-circular. While the cross-section could be circular, due to the geometry of the volume that the filter element 52 is installed within, it is sometimes convenient to have a non-circular cross-section. This cross-section permits a relatively large amount of media to economically occupy a small volume. In some preferred constructions, the cross-sectional configuration of the filter element 52 will be ob-round. In the particular embodiment shown in FIG. 5, the filter element 52 defines a cross-section that is racetrack shaped. By "racetrack shaped," it is meant that the filter element 52 defines a curved (in some embodiments, semicircular) end 160 and an opposite curved (in some embodiments, semicircular) end 162. The curved ends 160 and 162 are joined by a pair of straight segments 164, 166.

When using rolled constructions, such as the filter element 52, the system designer will want to ensure that the outer periphery of the filter element 52 is closed or locked in place to prevent the fluted media construction 122 from

unwinding. There are a variety of ways to accomplish this. In some applications, the outer periphery 168 is wrapped with a periphery layer 170. The periphery layer 170 can be a non-porous material, such as plastic with an adhesive on one side. In some embodiments, the periphery layer 170 may be a tough, durable material such as chip board or mylar. Still in other embodiments, the outer layer 170 may be a permeable media.

In reference again to FIG. 2, the filter element 52 is shown installed in the housing 52. In the arrangement shown, air flows into the housing 51 through the inlet 56, through the filter element 52, and out of the housing 51 at the outlet 58. The seal member 74 is needed to ensure that air flows through the filter element 52, rather than bypass it.

#### E. The Frame Construction and Sealing System

The frame construction 72 provides a support structure or backing against which the seal member 74 can be compressed to form radial seal 76 with the body member 80 of the housing 51.

Attention is directed to FIGS. 5-7. The frame construction 72 includes a frame 180. The frame 180 may be a variety of shapes. In the particular embodiment illustrated in FIGS. 5-7, the shape of the frame 180 is generally ob-round or racetrack shaped. The frame 180 is convenient in that it is arranged and configured for attachment to the outlet face 62 of the filter element 52.

The preferred frame 180 depicted includes a band, skirt, or depending lip 182 that is generally sized to mateably engage and receive the second end 66 of the filter element 52. The depending lip 182 preferably extends radially around the outlet face 62, such that the depending lip 182 extends inboard a distance over the filter element 52. In preferred arrangements, the frame 180 will be secured to the filter element 52 at the interface between the lip 182 and the inboard region that the lip 182 extends along the periphery layer 170.

The frame 180 also includes an annular sealing support 184 (FIG. 2) extending from the lip 182. Between the sealing support 184 and the lip 182, the frame 180 includes a step 186. The step 186 provides a transition area between a larger dimension of the lip 182 and a reduced dimension of the sealing support 184.

When constructed according to principles described herein, the sealing support 184 provides a rigid support surface for the seal member 74. The seal member 74 is preferably constructed and arranged to be sufficiently compressible to be squeezed or compressed between the sealing support 184 of the frame 180 and the second annular region 104 of the body member 80. When  
5 compressed between the support surface 184 and the second annular region 104, the radial seal 76 is formed between the filter element 52 and the body member 80 of the housing 51.

A variety of ways are possible to secure the seal member 74 to the sealing support 184. One particularly convenient and preferred way is by molding  
10 the seal member 74 to engage, cover, or overlap both the inner portion 188 and the outer portion 190 of the sealing support 184, including the end tip 192. One example of this is depicted in FIG. 2. The seal member 74 completely covers the sealing support 184, by wrapping around the inner portion 188, the end tip 192, and  
15 the outer portion 190.

The sealing support 184 acts as a support structure between and against which the radial seal 76 may be formed by the compressible seal member 74. The compression of the compressible seal member 74 is preferably sufficient to form radial seal 76 under insertion pressures of no greater than 80 lbs., typically, no  
20 greater than 50 lbs., for example about 20-30 lbs., and light enough to permit convenient and easy change-out by hand. Preferably, the amount of compression of the seal member 74 is at least 15%, preferably no greater than 40%, and typically between 20 and 33%. By the term "amount of compression," it is meant the physical displacement of an outermost portion of the seal member 74 radially toward the  
25 sealing support 184 as a percentage of the outermost portion of the seal member 74 in a resting, undisturbed state and not installed within the housing 51 or subject to other forces.

Attention is directed to FIG. 7. Preferably, the seal member 74 has a stepped cross-sectional configuration of decreasing outermost dimensions from a  
30 first end 194 to a second end 196 to achieve desirable sealing. Preferably, the seal member 74 will comprise a polyurethane foam material having a plurality (preferably, at least three) of progressively larger steps configured to interface with

the second annular region 104 (FIG. 2) and provide a fluid-tight seal. As can be seen in FIG. 7, the seal member 74 defines three steps 197, 198, and 199 that increase in dimension between the second end 196 and the first end 194. The smallest dimension at step 197 allows for easy insertion into the body member 80.

5 The largest dimension at step 199 ensures a tight radial seal 76.

In general, for a properly functioning radially sealing structure, the compressible seal member 74 needs to be compressed when the element 52 is mounted in the housing 51 (FIG. 2). In many preferred constructions, the seal member 74 is compressed between about 15% and 40% (often, about 20-33%) of its  
10 thickness to provide for a strong robust seal, yet still be one that can result from hand installation of the element 52 with forces on the order of 80 lbs. or less, preferably 50 lbs. or less, and generally about 20-30 lbs.

Attention is directed to FIG. 6. The preferred frame 180 includes a support system 205. During use of the filter element 52 depicted, inward forces are  
15 exerted around the outer periphery of the frame 180. Inward forces exerted against the curved ends 206, 208 can cause the straight segments 210, 212 to bow or bend. The support system 205 is provided as part of the frame 180 to prevent the straight segments 210, 212 from bowing. Further, the support system 205 also provides for engagement and connection with the handle member 70.

20 While a variety of structures are contemplated herein, in the particular embodiment illustrated in FIG. 6, the support system 205 includes a plurality of cross braces 214 to provide structural rigidity and support to the straight segments 210, 212. As can be seen in FIG. 6, the cross braces 214 form a truss system 216 between the opposing straight segments 210, 212. The truss system 216 includes a  
25 plurality of rigid members or struts 218, preferably molded as a single piece with the remaining portions of the frame 180.

As can also be seen in FIG. 6, the support system 205 provides engagement surfaces or members for the handle member 70 to connect with. This is described further below.

#### 30 F. Handle Member

The handle member 70 is now described in further detail. Preferably, the handle member 70 is secured to the filter element 52, and is constructed and

arranged to accommodate a grasping force applied by portions of a human hand. This permits convenient manipulation and handling of the filter element 52, particularly during servicing or changeout.

In preferred systems, the handle member 70 is secured to the element 52, such that a pulling force applied to the handle member 70 will translate into a pulling force applied to the filter element 52. In most preferred systems, the handle member 70 will be secured to a central core member 230 (FIG. 2), such that portions of the fluted construction 122 will not need to have obstructions or other connections made to accommodate the handle member 70.

The handle member 70 is preferably integral with the core member 230. Further, in the preferred embodiment shown in FIG. 2, the handle member 70 is molded as a single piece with the core 230. This single piece molding permits expedient, convenient manufacturing and assembly.

In preferred embodiments, the handle member 70 will comprise a center board 232 (FIG. 8) for use in the filter element 52. Attention is directed to FIG. 8. One preferred center board 232 is illustrated, in top plan view. The center board 232 depicted comprises an extension 234 having a first end 236 and an opposite, second end 238. The handle member 70 forms the first end 236, in the preferred embodiment shown. A fastening member 240 forms the second end 238. As briefly discussed above, the fastening member 240 is constructed and arranged to connect to the frame 180.

By having the fastening member 240 engage and be secured to the frame 180, the filter element 52 can be removed from the housing 51 by grasping handle member 70, and without having the coiled fluted construction 122 forming the filter media of the element 52 be "telescoped." In other words, by securing the handle member 70 to the frame 180, and in particular to the support system 205, when pulling forces are used on the handle member 70, the element 52 is prevented from being pulled out in a telescoping manner. That is, because of the engagement between the fastening member 240 and the support system 205, each of the inlet face 60 and outlet face 62 maintain a relatively flat, planar surface. The engagement between the fastening member 240 and the struts 218 in the truss system 226 help to distribute the pulling force exerted on the handle member 70 throughout the entire

cross-section of the filter element 52. The pulling force on the first end 64 of the element 52 is translated into a pulling force on the opposite, second end 66 of the element 52, and axially across the cross-section of the second end 66 of the element 52.

5                    Still in reference to FIG. 8, the center board 232 preferably includes first and second side edges 242, 244 extending between the first and second ends 236, 238.

                  While a variety of embodiments for fastening members 240 are possible and contemplated herein, in the particular embodiment illustrated in FIG. 8, 10 the fastening member 240 includes a hook construction 250. The hook construction 250 is for catching portions of the braces 214 of the support system 205. In the example illustrated in FIG. 8, the hook construction 250 includes a first hook 252 cantilevered from the extension 234 and being along the first side edge 242, and a second hook 254 cantilevered from the extension 234 and being along the second 15 side edge 244.

                  The first hook includes a recessed region 256 that forms a seat, and a cornered shoulder 258. A surface 260 is angled from the shoulder 258 to reach an end point 262. Extending from the end point 262 is preferably an edge 264 that extends inwardly, to define a cutout 266. In the embodiment shown, the cutout 266 20 is U-shaped. The cutout 266 permits the first hook 252 to deflect in a direction toward the second side edge 244. The angled surface 260 abuts and slides along the braces 214, to allow for the deflection of the first hook 252, until the brace 214 engages within the recessed region 256.

                  It should be appreciated that the deflection permitted by the cutout 25 266 allows for convenient, quick engagement and connection between the center board 232 and frame 180. In particular, the first hook 252 deflects in a direction toward the second side edge 244, which allows one of the braces 214 to be seated within the recessed region 256 and be trapped by the cornered shoulder 258. Preferably, the deflection is at least 1 mm, no greater than about 20 mm, and 30 typically about 1.5-5 mm.

                  The second hook 254 is constructed analogously as the first hook 254. As such, the second hook 254 includes a recessed region 276 as a seat for

holding the braces 214. The second hook 254 includes a cornered shoulder 278, an angled surface 280, an end point 282, an edge 284, and a U-shaped cutout 286.

FIG. 7 shows the element 52 before the fastening member 240 has been snapped or hooked into place with the support system 205 of the frame 180.

- 5 The filter element 52 is lowered into the frame 180, and the first and second hooks 252, 254 are deflected inwardly or toward each other, until the recessed regions 256, 276 of the hooks 252, 254 are snapped or engaged into the braces 214.

- Referring again to FIG. 8, the handle member 70 is now described in further detail. Handle member 70 preferably includes at least one projection 290 axially extending from the first end 64 of the filter element 52 (FIG. 2). Attention is directed to FIG. 2. As can be seen in FIG. 2, the first projection 290 is oriented closer to the first side edge 242 than to the second side edge 244. In the particular preferred embodiment illustrated, the first projection 290 is even with the first side edge 242. The first projection 290 preferably has an aperture 292 extending
- 10 therethrough to accommodate portions of a human hand, such as a few fingers.

- There is also preferably a second projection 294 extending axially from the first end 64 of the filter element 52. The second projection 294 is preferably spaced apart from the projection 290 by distance 100 (FIG. 2) in order to accommodate the extension 90 from the cover 82 of the housing 51. The projection
- 20 294 preferably includes an aperture 296 extending therethrough sized to accommodate portions of a human hand, such as a few fingers. It can be seen that the second projection 294 is closer to the second side edge 244 than it is to the first side edge 242. In the preferred embodiment illustrated, the second projection 294 is even with the second side edge 244.

- The center board 232 defines a recessed portion 298 (FIG. 8) extending between the first projection 290 and second projection 294. The second projection 294 is preferably located between the first projection 290 and the second side edge 244; similarly, the first projection 290 is preferably located between the second projection 294 and the first side edge 234. The preferred embodiment
- 25 includes the recessed portion 298 extending between the first projection 290 and the second projection 294.
- 30

Preferably, the recessed portion 298 has a rigid, straight edge 300 extending between and connecting the first and second projections 290, 294. The edge 300 is used to engage and receive the projection 88 from the cover 82 (FIG. 2). In normal use, there is no engagement between the projection 88 and the edge 300.

5 If there is engagement, it may indicate to the user that the element 52 is not properly installed in the housing 51. Engagement between the extension 90 and edge 300 will prevent securing the cover 82 to the body member 80. During use, there can be some engagement, if the element 52 vibrates in the body member 80. In those instances, the extension 90 will help to hold the element 52 in a properly installed

10 position (with the radial seal 76 in place). The extension 90 is properly oriented in the void 100 created by the recessed portion 298.

Referring again to FIG. 8, there is preferably a system 305 for helping to hold the fluting sheet 130 in place, to prevent slippage and bowing outwardly, during assembly. In the illustrated embodiment, this system 305 is integral with the

15 center board 232. In particular, the center board 232 includes a region of corrugations 310 located on the extension 234 between the first and second ends 236, 238. The region of corrugation 310 is preferably constructed and arranged to mate with flutes 124 of the fluted sheet 130, during construction and assembly of the filter element 52. When initially assembling the filter element 52, the fluted sheet

20 130 is wound around the center board 232. In some applications, the fluted sheet 130 will have a memory built in, and inherently will want to bow outwardly, radially in a direction away from the center board 232. It becomes difficult to create a secure, tight seal, when this is occurring. To rectify this, the region of corrugations 310 is in the center board 232, because the fluted sheet 130 is better able to mate and

25 engage with the center board 232, than with a flat surface.

In reference now to FIG. 9, the region of corrugation 310 preferably includes a plurality of corrugations 312. In particular, the plurality of corrugations includes a plurality of peaks 322 alternating with a plurality of troughs 324. In the embodiment illustrated in FIG. 8, the corrugations 312 extend continuously between

30 the first edge 242 and the second edge 244. In preferred embodiments, there will be at least 5 peaks 322 and 5 troughs 324; no more than about 100 peaks 322 and no more than about 100 troughs 324; and preferably between 10-50 peaks 322 and



about 10-50 troughs 324. The corrugations 312 also help to prevent slippage of the fluted sheet 130 relative to the center board 232, during winding. In other words, the region of corrugation 310 provides a bearing surface to help hold and secure the fluted sheet 130 to the center board 232 during winding and manufacturing.

5           Note that in the embodiment of FIG. 8, the region of corrugations 310 extends only partially along the length of the extension 234. Preferably, the length of the region or corrugations 310 will extend at least 1 inch downwardly from the edge 300. In other embodiments, the region of corrugations 310 can extend the entire length between the edge 300 and an opposite edge 314 at the second end 238.

10       Some minimal length of the corrugations 310 is desired because the adhesive securing the fluted sheet 130 and the center board 232 will extend only a partial distance along the center board 232. But, the region of corrugations 310 can also extend the entire length between the edge 300 and edge 314, because the corrugations 312 provide a bearing surface for winding the fluted sheet 130 around

15       the center board 232.

          During construction of the filter element 52, the center board 232 may be placed on a spindle and held at cutout 316. Adhesive is placed along the region of corrugations 310, and the fluted sheet 130 is placed over the adhesive. The flutes 124 mate with the individual corrugations 312 of the center board 232. The

20       center board 232 is then turned about a central axis, while the fluted construction 122 is formed around the center board 232.

          The individual corrugations 312 can be a variety of sizes. Preferred corrugations 312 will be of a size to mate with the individual flutes in the fluted sheet 130. One size includes: a peak to peak width 326 of about 5-7 mm, for

25       example, about 6.5 mm; a trough to peak height 328 of about 1-4 mm, for example, about 2.5 mm; a radius on each peak 322 of about 0.5-2 mm, for example, about 1 mm; a radius on each trough 324 of about 1-3 mm, for example, about 1.3 mm; a peak to peak depth 330 of about 6-10 mm, for example, about 7.9 mm; and a trough to trough width 332 of about 5-8 mm, for example, about 6 mm.

30       Another size includes: a peak to peak width 326 of about 6-10 mm, for example, about 8.4 mm; a trough to peak height 328 of about 2-6 mm, for

example, about 4.3 mm; and a trough to trough width 332 of about 6-10 mm, for example, about 8.4 mm.

Another size includes: a peak to peak width 326 of at least 5 mm, no greater than 9 mm--for example, about 7.6 mm; a trough to peak height 328 of at least 2 mm, no greater than 5 mm--for example, about 3.3 mm; a peak to peak depth 330 of at least 1 mm, no greater than 6 mm--for example, about 3.3 mm; and a trough to trough width 332 of at least 4 mm, no greater than 10 mm--for example, about 7.6 mm.

Referring again to FIG. 8, the preferred center board 232 includes a plurality of apertures or holes 320. The holes 320 help to create a lightweight center board 232. The holes 320 can be in any pattern.

#### G. Methods of Operating, Servicing, and Assembling

In operation, gas to be cleaned, such as airflow being taken into equipment 22, will be initially sucked into the air cleaner 50 and directed through inlet 56. The air will then flow through the inlet face 60 of the filter element 52. The air will enter the flute chambers 136 that are opened at the upstream end 64. The air will be forced to flow through either the fluting sheet 130 or the face sheet 132, and as such, have particulates removed therefrom. The cleaned air will then exit at the outlet face 62. That is, the cleaned air will exit through the flutes 134 that are open at the second end 66. The cleaned air will then flow through the outlet 58, and be directed to downstream components, such as engine 24. The uncleaned air is prevented from bypassing the filter element 52 by the radial seal 76 between the filter element 52 and the housing 80.

After a certain period of operation, the air cleaner 50 will require servicing. The filter element 52 will become occluded and require replacing. Typically, the filter element 52 should be removed and replaced when the restriction reaches at least 25 inches of water. To service the air cleaner 50, the cover 82 is removed from the body member 80. This is done by removing the bolts 86 and then removing the cover from the body member 80 to expose the opening 84. This provides access to the interior 54 of the body member 80. When the cover 82 is removed from the body member 80, the element engaging end 96 of the extension

90 is removed from the void 100 of the recessed portion 298 of the handle member 70.

Next, the user grasps the filter element 52. Preferably, this is done by grabbing the handle member 70. In the preferred embodiment, this is done by inserting at least one finger of one hand in the aperture 292, and another finger of the other hand in aperture 296. The user then applies a pulling force to the handle member 70. This translates into a pulling force on the extension 234, and ultimately onto the frame construction 72. That is, the pulling force is transferred through the fastening member 240 to the support system 205. The pulling force will move the filter element 52 in an axial direction, such that the seal member 74 moves from the second annular region 104 to the first annular region 102. This breaks the radial seal 76.

The filter element 52 is then removed through the opening 84 outside of the air cleaner 50. The old filter element 52 may then be disposed of. This may be accomplished by incinerating the entire filter element 52, including the center board 232. Alternatively, the fluted media construction 122 may be separated from the center board 232, such that the center board 232 may be reused. Or, alternatively, after the fluted construction 122 is removed from the center board 232, each can be disposed of in separate recycling programs.

A second, new, filter element 52 is then supplied. The new filter element 52 is inserted through the opening 84 of the body member 80. The user may manipulate the filter element 52 by grasping the handle member 70, through its projections 290, 294. The filter element 52 is inserted into the housing 51, until the radial seal 76 is formed. In the illustrated embodiment, this is done by pushing the filter element 52 into the body member 80, until the end 196 of the seal member 74 abuts or engages the end wall 108 of the second annular region 104.

The cover 82 is then oriented over the open end 84. As this is done, the extension 90 is lowered into the interior 54. If the filter element 52 has not been properly seated within the seat of the annular region 104, the extension 90 will engage the edge 300 of the handle member 70 and prevent the cover 82 from being properly seated on the body member 80. If the filter element 52 is properly seated within the seat of the annular region 104 (and the radial seal 76 is in place), then the

cover 82 will be permitted to properly fit onto the body member 80. The extension 90 will rest in the void 100. The cover 82 is then secured to the body member 80, by tightening the bolts 86. The air cleaner 50 is then ready to be operated again.

To construct preferred filter elements 52 as described herein, first,  
5 the center board 232 is provided. The center board 232 may be made using conventional techniques, such as injecting molding.

Next, adhesive is applied to the region of corrugations 310. In the preferred embodiment of FIG. 8, adhesive is applied only to a portion of the region of corrugations 310. In particular, adhesive is applied only along about the upper  
10 one-third of the region of corrugations 310, completely between edge 242 and edge 244. By "upper portion," it is meant the portion that is closer to the handle member 70 than to the fastening member 240. In other embodiments, the adhesive can be along the entire length of the region of corrugations 310, or less than the upper one-third, for example, the upper 10-25%. It should be noted that adhesive is applied on  
15 both top and bottom sides of the region of corrugation 310 of the center board 232.

The fluting sheet 130 is then laid over the center board 232. Individual flutes of the fluting sheet 130 are mateably engaged with individual corrugations 312 of the region of corrugation 310. The adhesive joins the fluting sheet 130 to the extension 234. The fluting sheet 130 is wrapped around the center  
20 board 232 completely. In other words, the first layer of the fluting sheet 130 will completely circumscribe both the top and bottom side of the center board 232. The region of corrugations 310 will help to keep the fluting sheet 130 tightly against the center board 232. The region of corrugations 310 will also provide a bearing surface to help wind the fluted construction 122 therearound.

25 Preferably, the center board 232 is held at notch 316 by the spindle of a machine. The machine spindle will turn the center board 232 about its central longitudinal axis, to wind the fluting sheet 130 and face sheet 132 around the center board 232.

After the fluted construction 122 is wound around the center board  
30 232, the center board 232 is secured to the frame construction 72. In preferred embodiments described herein, the fastening member 240 is connected or secured to the braces 214 of the support system 205. This is done by lowering the center board

232 with the media construction 122 secured thereto into the frame 180. The angled surfaces 260, 280 will cam or be pushed against the braces 214. The cutouts 266, 286 will allow the hooks 252, 254 to deflect inwardly, toward each other. The cornered shoulders 258, 278 will then snap over the braces 214. This will trap the braces 214 into the recesses 256, 276. Typically, before the centerboard 232 is connected to the frame 180, adhesive will be applied along the inner surface of the lip 182, to secure the outer layer 170 to the lip 182 of the frame 180. The filter element 52 may then be installed in the air cleaner housing 51.

#### H. Example Materials and Dimensions

The following section includes usable materials and dimensions of specific embodiments. Of course, a wide variety of materials and dimensions may be utilized.

Preferably, the housing 51 is constructed of plastic, for example glass filled nylon. The extension 90 will have a length of at least about 50 mm, and no greater than about 500 mm. The extension 90 will have a width 98 of at least about 5 mm, no greater than about 50 mm, and typically about 10-40 mm. As a percentage of the distance 100, the width 98 of the extension 90 will be at least about 10%, no greater than 95%, and typically about 25-75% of the distance 100.

The filter element 52 will have an overall length extending between its inlet face 60 and outlet face 62 of at least about 100 mm, no greater than about 500 mm, and typically about 200-300 mm. It will have a major dimensional width of at least about 100 mm, no greater than about 400 mm, and typically about 200-300 mm. It will have a minor dimensional width of at least about 25 mm, no greater than about 250 mm, and typically about 50-150 mm.

The filter element 52 can be constructed of cellulose. One example of usable cellulose media is: a basis weight of about 45-55 lbs./3000 ft<sup>2</sup> (84.7 g/m<sup>2</sup>), for example, 48-54 lbs./3000 ft<sup>2</sup>; a thickness of about 0.005-0.015 in, for example about 0.010 in. (0.25 mm); frazier permeability of about 20-25 ft/min, for example, about 22 ft/min (6.7 m/min); pore size of about 55-65 microns, for example, about 62 microns; wet tensile strength of at least about 7 lbs/in, for example, 8.5 lbs./in (3.9 kg/in); burst strength wet off of the machine of about 15-25 psi, for example, about 23 psi (159 kPa). The cellulose media can be treated with fine fiber, for

example, fibers having a size (diameter) of 5 microns or less, and in some instances, submicron. A variety of methods can be utilized for application of the fine fiber to the media. Some such approaches are characterized, for example, in U.S. Patent 5,423,892, column 32, at lines 48-60. More specifically, such methods are described  
5 in U.S. Patent Nos. 3,878,014; 3,676,242; 3,841,953; and 3,849,241, incorporated herein by reference. An alternative is a trade secret approach comprising a fine polymeric fiber web positioned over conventional media, practiced under trade secret by Donaldson Company under the designation ULTRA-WEB®. With respect to the configurations of the filter element, there is no particular preference  
10 for: how the fine fibers are made; and, what particular method is used to apply the fine fibers. Enough fine fiber would be applied until the resulting media construction would have the following properties: initial efficiency of 99.5% average, with no individual test below 90%, tested according to SAE J726C, using SAE fine dust; and an overall efficiency of 99.98% average, according to SAE  
15 J726C.

The center board 232 will have an overall length of at least about 100 mm, no greater than about 800 mm, and typically about 200-500 mm. It will have an overall width between side edge 242 and side edge 244 of at least about 50 mm, no greater than about 500 mm, and typically about 100-200 mm. Each of the  
20 projections 290, 294 will extend above the first end 64 by a distance of at least about 20 mm, no greater than about 200 mm, and typically about 40-100 mm. The distance 100 between the inside edges of the projections 290, 294 is at least about 25 mm, no greater than about 300 mm, and typically about 50-150 mm. Each of the apertures 292 will have an outermost dimension (preferably, a diameter) of at least  
25 about 10 mm, no greater than about 150 mm, and typically about 20-70 mm.

The length of the region of corrugations 310 will preferably be at least about 20 mm, no greater than about 200 mm, and typically about 50-100 mm. There will preferably be at least 5, no greater than about 100, and typically about 10-30 individual corrugations 312.

Each of the angled surfaces 260, 280 on the hooks 252, 254 will  
30 extend at an angle relative to the central longitudinal axis of the center board 232 of at least about 30°, no greater than about 60°, and typically about 40-50°. Each of the

recesses 256, 276 will have a width of at least about 4 mm, no greater than about 25 mm, and typically about 5-15 mm. Each of the cutouts 266, 286 will extend at least about 10 mm, no greater than about 80 mm, and typically about 20-50 mm from the bottom edge 314.

5                   The center board 232 will have an overall thickness of at least about 1 mm, no greater than about 20 mm, and typically about 2-10 mm. The center board 232 will have an overall weight of at least about 2 oz., no greater than about 10 oz., and typically about 4-6 oz. There will be at least 1 hole 320, no greater than about 100 holes 320, and typically about 25-35 holes 320. Preferably, the center board  
10 232 will be constructed of plastic, such as glass filled nylon, preferably 13% glass filled nylon.

                  Preferably, the frame 180 will be constructed from plastic, such as 33% glass filled nylon. The seal member 74 can be constructed from foamed polyurethane having an as molded density of about 11-22 lbs/ft<sup>3</sup>. One usable foamed  
15 polyurethane is described in U.S. Patent No. 5,669,949, incorporated herein by reference.

                  The above specification, examples, and data provide a complete description of the manufacture and use of the invention. Many embodiments of the invention can be made.

We claim:

1. A filter arrangement comprising:
  - (a) a filter element having opposite first and second ends; said filter element comprising a plurality of flutes;
    - (i) each of said flutes having a first end portion adjacent to said filter element first end, and a second end portion adjacent to said filter element second end;
      - (A) selected ones of said flutes being open at said first end portion and closed at said second end portion; and  
selected ones of said flutes being closed at said first end portion and open at said second end portion;
  - (b) a handle member secured to said filter element adjacent to said first end; and
  - (c) a frame construction secured to said filter element adjacent to said second end.
2. A filter arrangement according to claim 1 wherein:
  - (a) said handle member is secured to said frame construction.
3. A filter arrangement according to claim 2 wherein:
  - (a) said frame construction includes a plurality of support braces extending at least partially over one of said first and second ends of said filter element; and
  - (b) said handle member includes a pair of hooks engaging said support braces.
4. A filter arrangement according to any one of claims 2 and 3 wherein:
  - (a) said frame construction includes an extension projecting axially from one of said first and second ends;
    - (i) said extension of said frame arrangement supporting a seal member.



5. A filter arrangement according to claim 4 wherein:
  - (a) said extension includes an inner portion, an outer portion, and an end tip;
  - (b) said seal member comprises polyurethane having an as molded density of 11-22 lbs/ft<sup>3</sup>;
    - (i) said seal member covering at least part of said outer portion, said inner portion, and said end tip of said extension.
6. A filter arrangement according to any one of claims 4 and 5 wherein:
  - (a) said seal member defines a cross-sectional configuration of steps.
7. A filter arrangement according to any one of claims 2-6 wherein:
  - (a) said filter element further includes a central core member, said plurality of flutes being coiled around said central core member.
8. A filter arrangement according to claim 7 wherein:
  - (a) said handle member is secured to said central core member.
9. A filter arrangement according to claim 8 wherein:
  - (a) said handle member and said central core member are a single-molded construction.
10. A filter arrangement according to any one of claims 7-9 wherein:
  - (a) said central core member includes a plurality of corrugations; said corrugations mateably engaging at least some of said flutes.
11. A filter arrangement according to any one of claims 7-10 wherein:
  - (a) said handle member comprises at least a single aperture defined by said central core member.

12. A filter arrangement according to claim 11 wherein:
- (a) said central core member includes first and second opposite ends;
    - (i) said handle member being part of said first end of said central core member, and projecting from said first end of said filter element; and
    - (ii) a hook construction being part of said second end of said central core member;
      - (A) said hook construction engaging said frame construction.
13. A filter arrangement according to claim 1 further including:
- (a) a board at least partially extending into said filter element; said board including:
    - (i) first and second opposite ends;
    - (ii) first and second opposite side edges extending between said board first and second opposite ends;
    - (iii) a first projection axially extending from said first end of said filter element;
      - (A) said first projection being oriented closer to said first side edge than to said second side edge; and
    - (iv) a recessed portion adjacent to said first projection.
14. A filter arrangement according to claim 13 wherein:
- (a) said board further includes a second projection axially extending from said first end of said filter element;
    - (i) said second projection being located between said first projection and said second side edge; and
    - (ii) said recessed portion extending between said first projection and said second projection.

15. A filter arrangement according to claim 14 wherein:
  - (a) said recessed portion comprises a straight segment of said board along said board first end;
  - (b) said first projection is immediately adjacent to said first side edge; and
  - (c) said second projection is immediately adjacent to said second side edge.
16. A center board for use in a filter element; the center board comprising:
  - (a) an extension having first and second, opposite ends; and
  - (b) a region of corrugation located on said extension between said first and second ends;
    - (i) said region of corrugation including a plurality of peaks alternating with a plurality of troughs.
17. A center board according to claim 16 wherein:
  - (a) each of the peaks is spaced from a next adjacent peak by a distance of at least 5 mm; and each of the troughs is spaced from a next adjacent trough by a distance of at least 5 mm; and
  - (b) said region of corrugation includes at least 5 peaks and at least 5 troughs.
18. A center board according to any one of claims 16 and 17 further comprising:
  - (a) a handle member forming said first end; and
  - (b) a fastening member forming said second end;
    - (i) said fastening member being constructed and arranged to connect to a frame construction of the filter element.
19. A center board according to claim 18 wherein:
  - (a) said handle member comprises at least a single aperture through said extension; and
  - (b) said fastening member includes a hook construction.

20. A center board according to claim 19 wherein:
- (a) said extension includes a first side edge extending between said first and second ends; and an opposite, second side edge extending between said first and second ends; and
  - (b) said hook construction includes:
    - (i) a first hook cantilevered from said extension; said first hook being along said first side edge;
    - (ii) a second hook cantilevered from said extension; said second hook being along said second side edge.
21. A center board according to claim 20 wherein:
- (a) said extension defines a first cut-out adjacent to said first hook; said first hook being constructed and arranged to deflect at least 1 mm; and
  - (b) said extension defines a second cut-out adjacent to said second hook; said second hook being constructed and arranged to deflect at least 1 mm.
22. An air cleaner comprising:
- (a) a housing having a body member and a cover; said body member defining an interior and an open end;
    - (i) said cover being selectively moveable from the open end of the body member to provide access to said interior;
  - (b) a filter element removably positioned in said interior; said filter element having first and second, opposite flow faces;
  - (c) a center board extending at least partially into said filter element; said center board including a first portion axially extending from said first flow face; said center board including a recess adjacent to said first portion; and

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- (d) a stay member being oriented in said recess, when said filter element is operably installed in said interior and when said cover is operably oriented over the open end of the body member.
23. An air cleaner according to claim 22 wherein:
- (a) said stay member comprises a projection extending from said cover;
  - (b) said first portion comprises a first handle member axially extending from said first flow face;
  - (c) said center board further includes a second handle member axially extending from said first flow face;
    - (i) said recess extending between said first and second handle members.
24. An air cleaner according to any one of claims 22 and 23 further comprising:
- (a) a seal member constructed and arranged to form a radial seal between and against said housing and said frame construction.
25. An air cleaner according to any one of claims 22-24 wherein:
- (a) said filter element comprises fluted filter media; and
  - (b) said center board includes a corrugated region;
    - (i) said corrugated region mateably engaging portions of said fluted filter media.
26. A method for servicing an air cleaner; the method comprising:
- (a) providing a filter element installed in a housing, wherein the filter element includes opposite upstream and downstream ends; the filter element having a plurality flutes, each of the flutes having a first end portion adjacent to the filter element upstream end, and a second end portion adjacent to the filter element downstream end; selected ones of the flutes being open at the first end portions and closed at the second end portions, and selected ones of the flutes being closed at

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the first end portions and open at the second end portions; the filter element further including a frame construction secured thereto;

- (b) grasping a handle projecting from one of the upstream and downstream ends; the handle being secured to the frame construction; and
- (c) pulling the handle to remove the filter element from the housing.

27. A method according to claim 26 wherein:

- (a) after said step of pulling the handle to remove the filter element from the housing, providing a second filter element; the second filter element having an axial projection extending therefrom and a recessed portion adjacent to the axial projection;
- (b) orienting the second filter element in the housing; and
- (c) orienting a stay member in the recessed portion.

28. A method according to claim 27 wherein:

- (a) the housing includes a body member and a cover; and
- (a) said step of orienting a stay member includes placing the cover over the body member; the stay including a projection extending from the cover.

29. A method for constructing an air filter element; the method comprising:

- (a) providing a center board; the center board having first and second, opposite ends; and a region of corrugation at least partially located between the first and second ends; and
- (b) aligning selected flutes of fluted filter media with the region of corrugation; and
- (c) winding the fluted filter media around the center board.

30. A method according to claim 29 further comprising:

- (a) before the step of aligning, applying adhesive to the region of corrugation;

- (b) after said step of winding, securing the center board to a frame construction; and
- (c) wherein said step of securing includes engaging a hook on the center board to a support brace on the frame construction.

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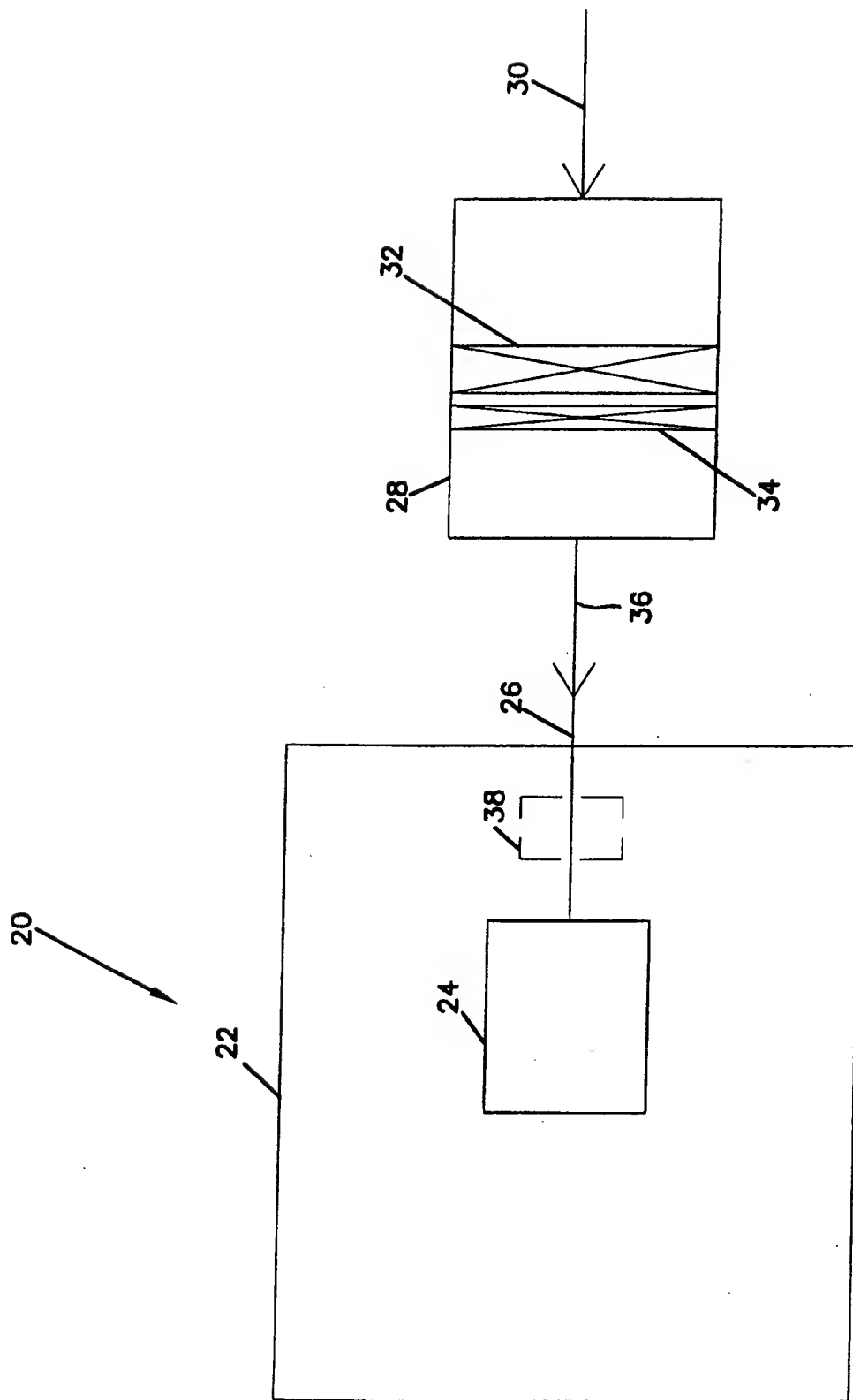
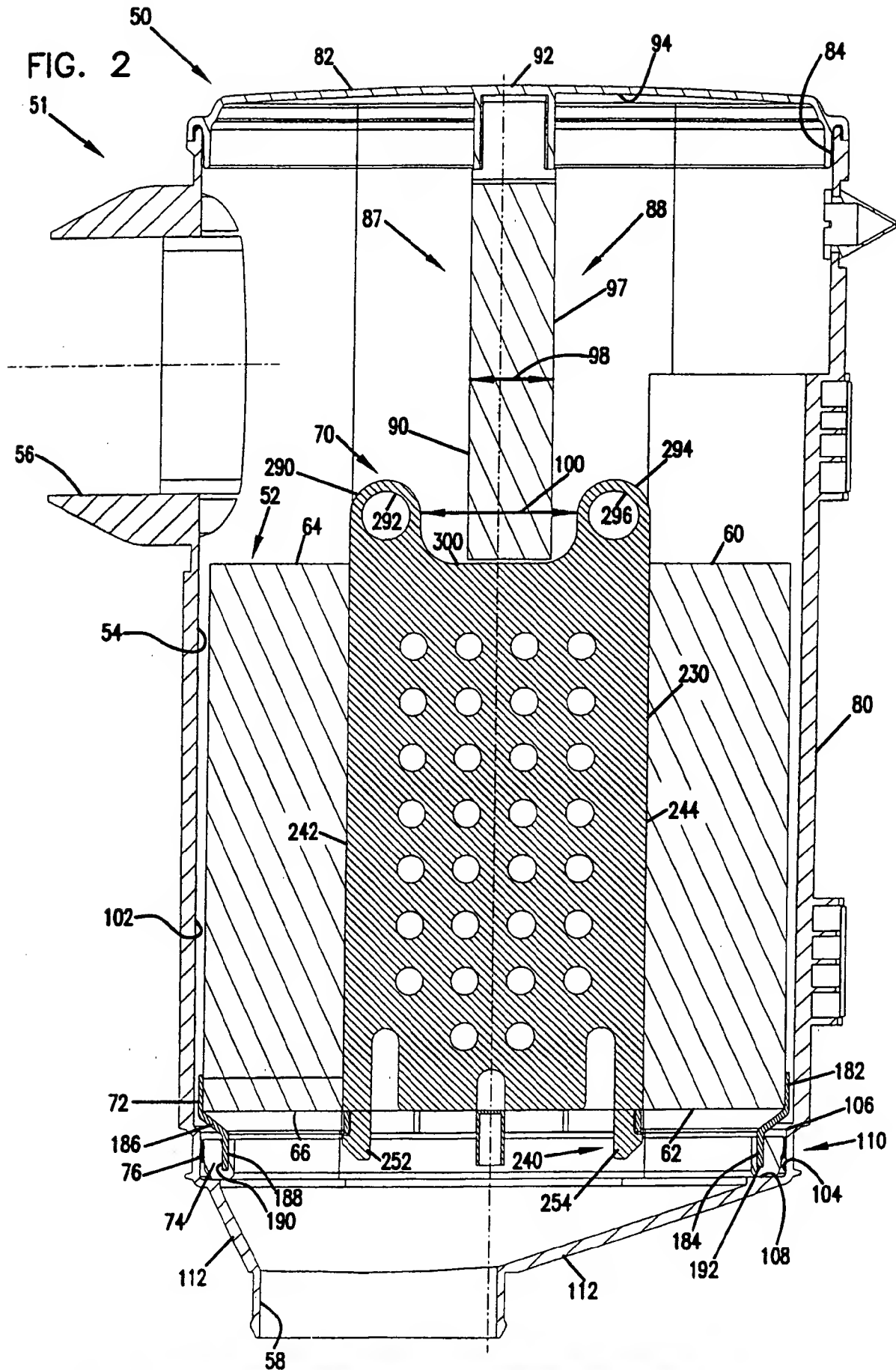


FIG. 1





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FIG. 3

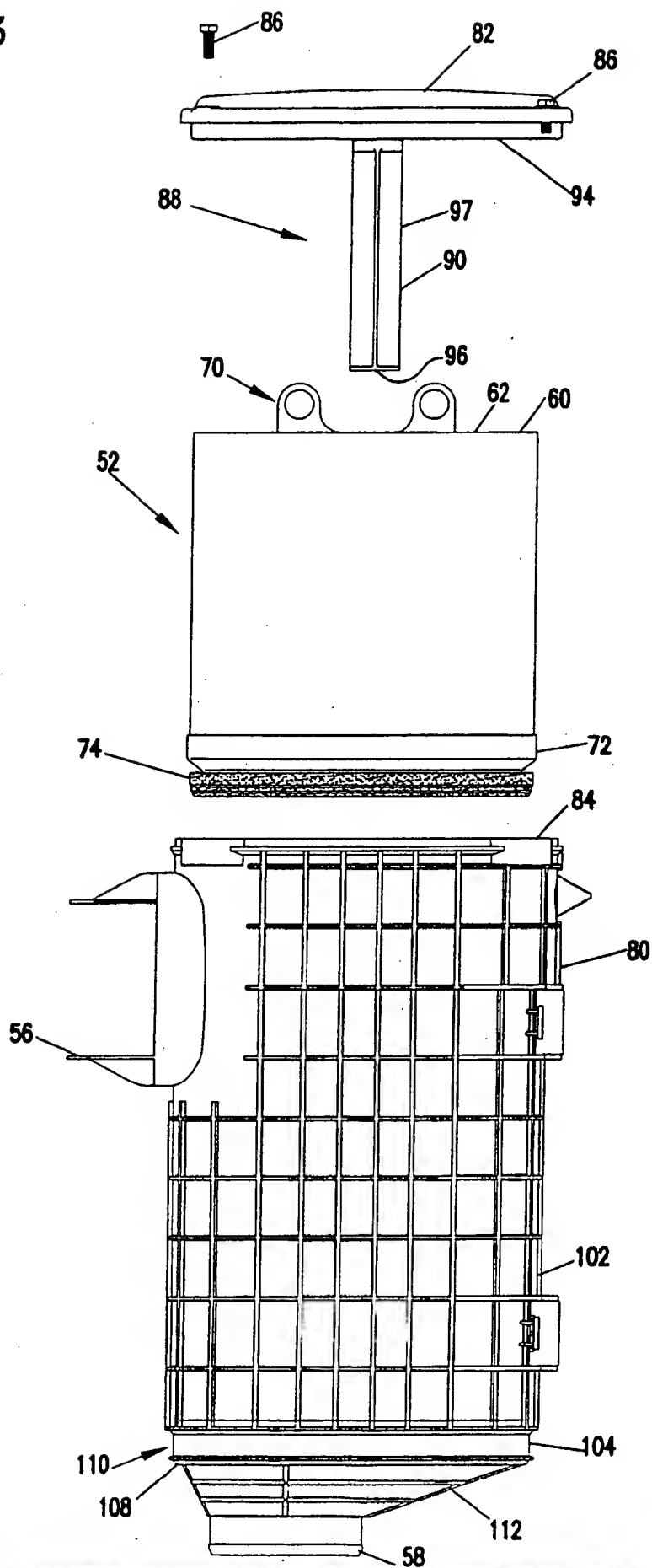


FIG. 4

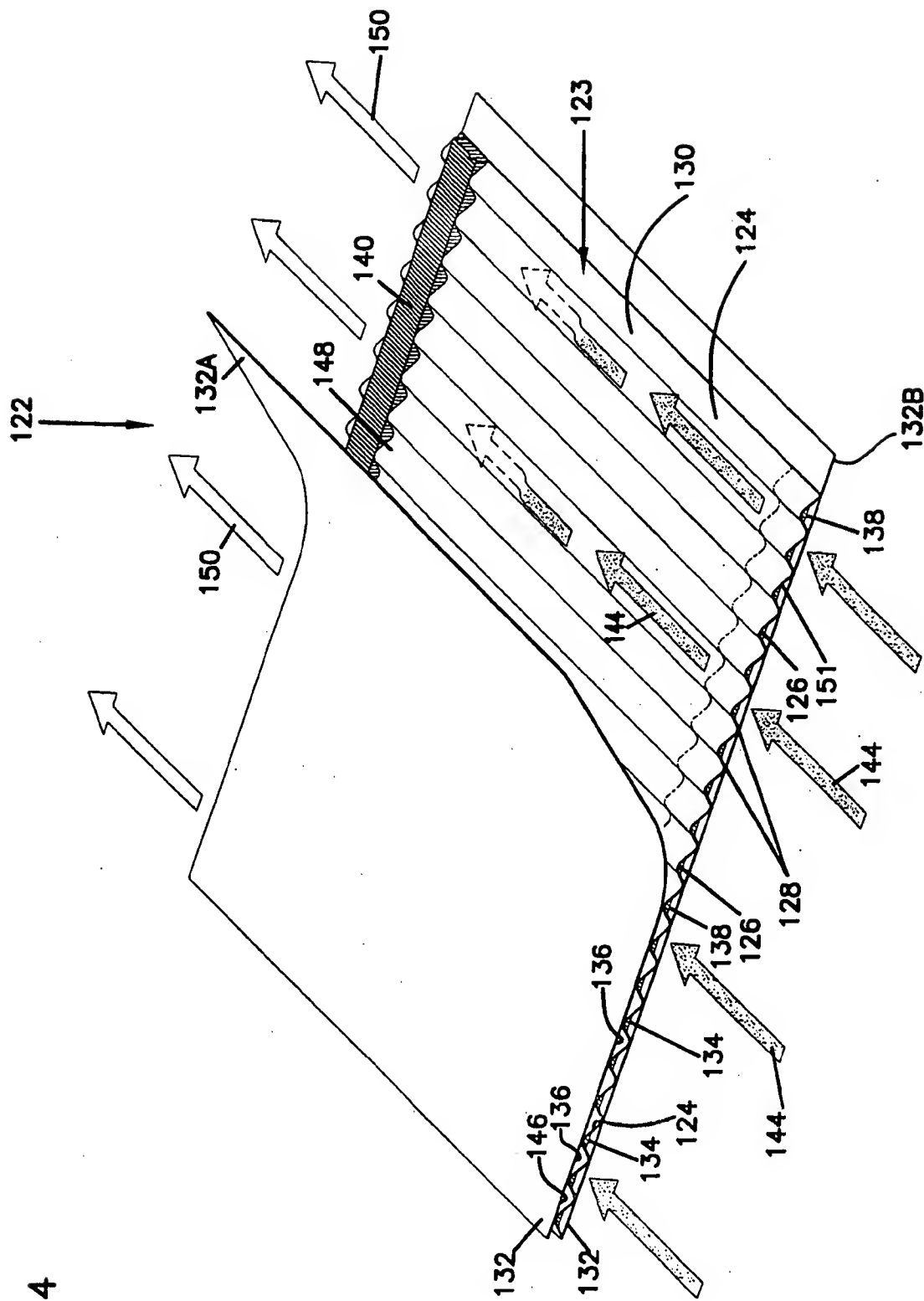


FIG. 5

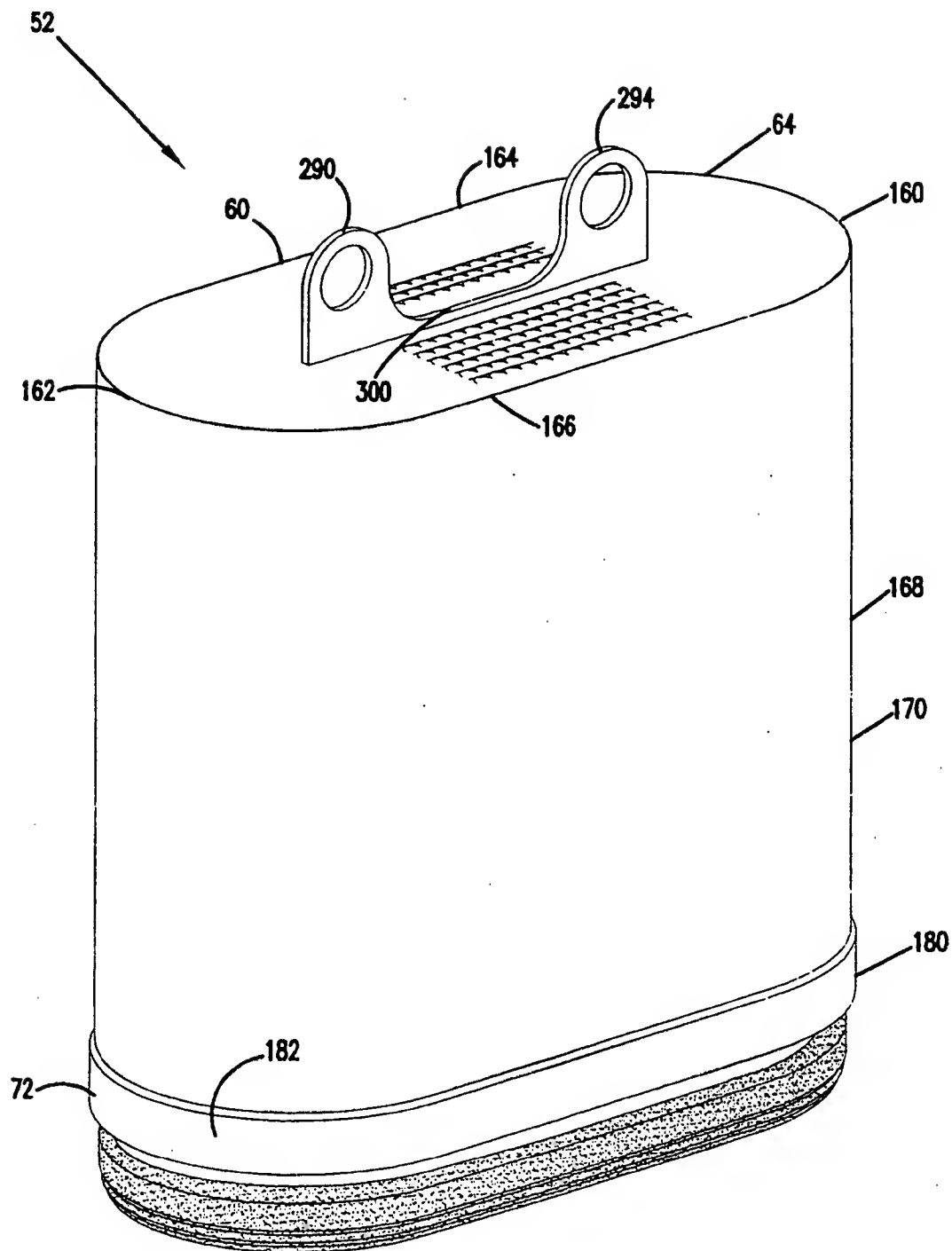
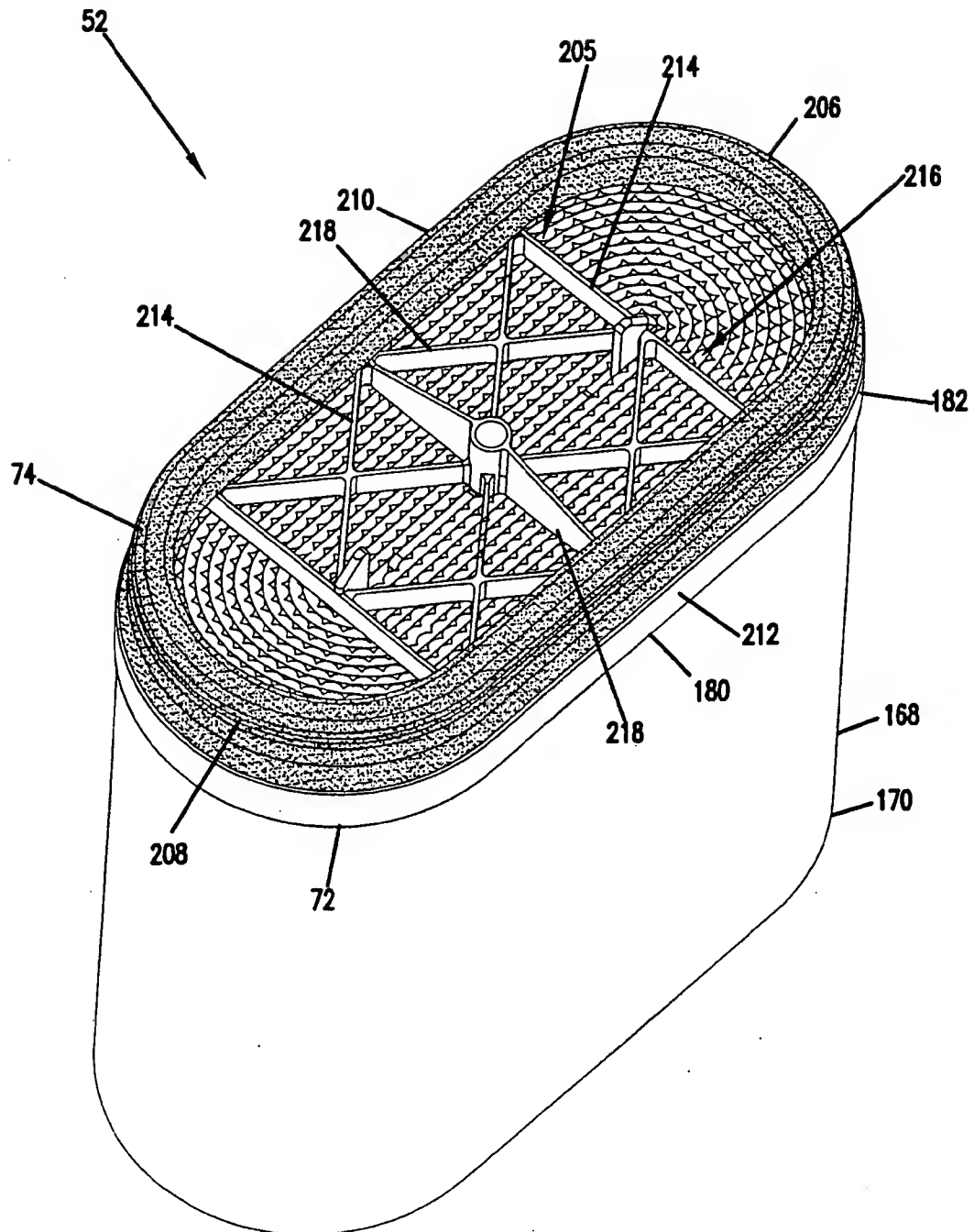


FIG. 6



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FIG. 7

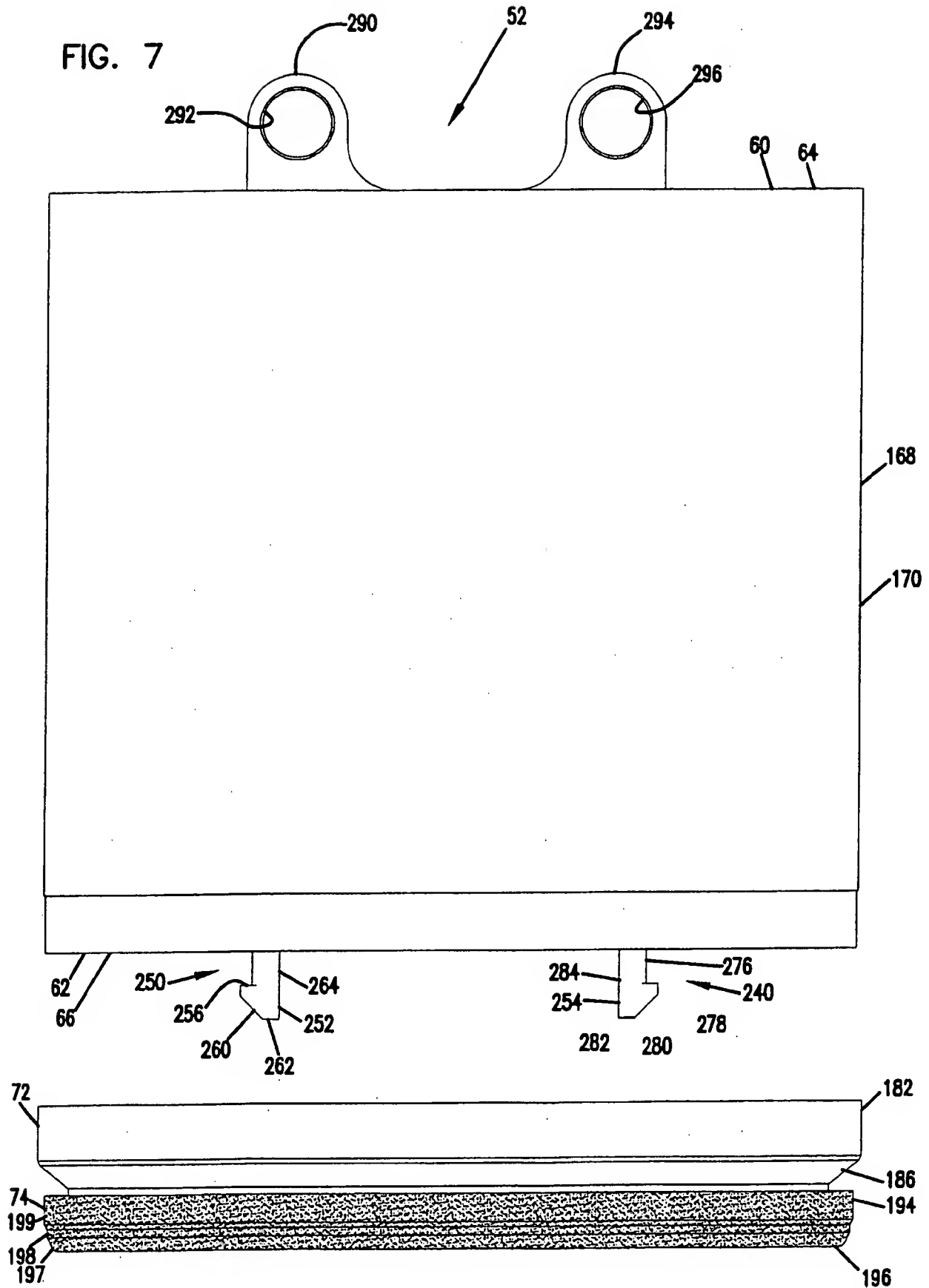


FIG. 8

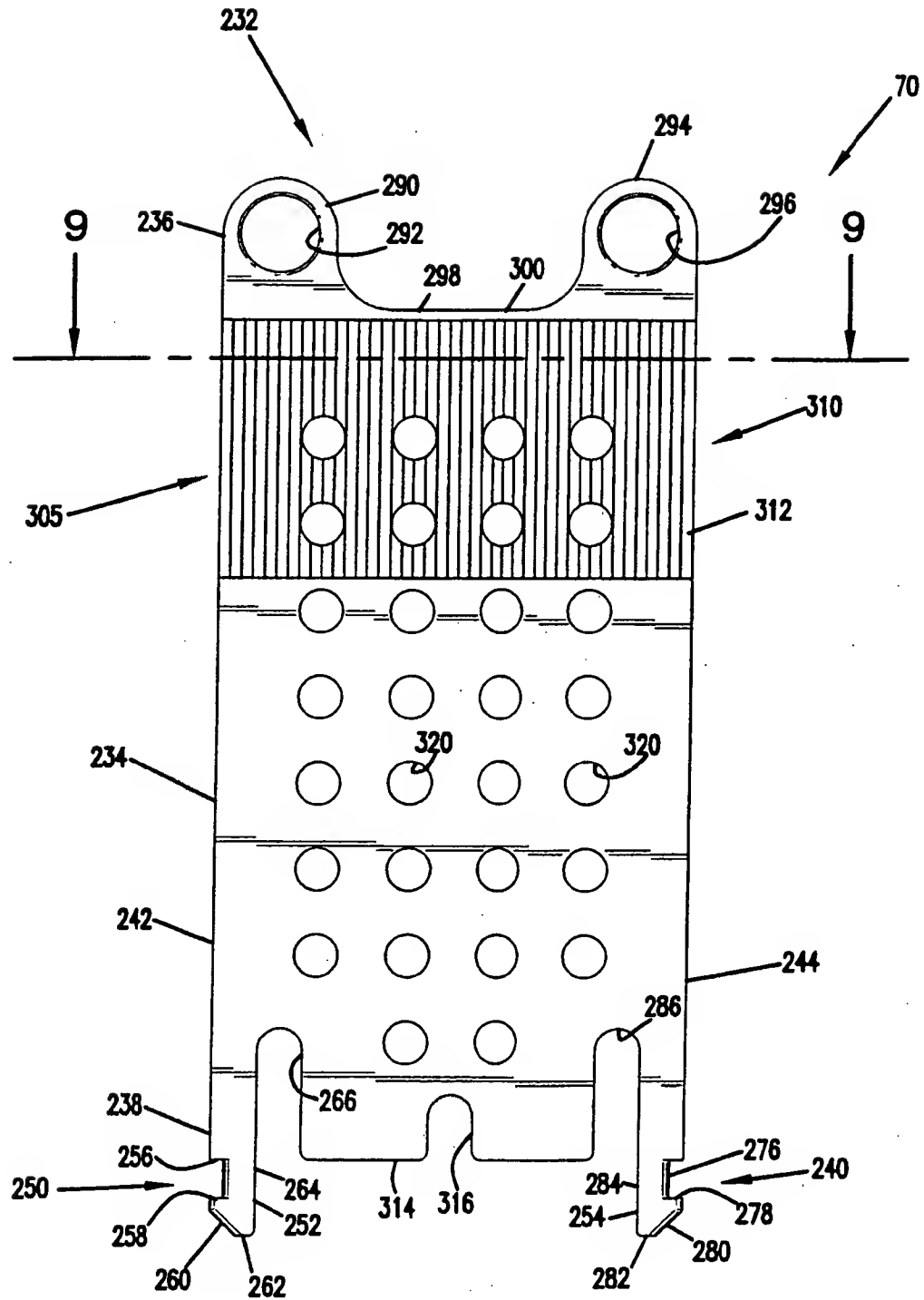


FIG. 9

